**Interface and File IO Design Document for UEBGrid**

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The current version of UEB is configured as a point model to produce outputs of snowmelt at a point driven by the inputs at that point. As part of this project we will develop a modified version of UEB called “UEBGrid” that loops over grid cells in the model domain and for each grid cell loops over all time steps. This document describes the overall design of “UEBGrid” which includes control files and input and output file descriptions etc. Input variables are classified into four groups.

* Spatially constant and constant in time. (SCTC). These are essentially model parameters.
* Spatially variable but constant in time (SVCT). These are site variables like slope, aspect and vegetation, quantities that characterize each point where UEB is being applied
* Spatially constant but time varying (SCTV). Some of these may be quantities that vary in time, like precipitation, wind, humidity, but for which there is not information about spatial variability.
* Spatially variable and variable in time (SVTV)

Spatially variable inputs (and outputs) will be handled using spatial grid files. NetCDF has been selected as the file format to use for grid files for the following reasons.

1. It has been designed to accommodate multiple time steps
2. It has reasonable support for Fortran (at least the 3.6.1 version)

Model parameters are always SCTC. Site Variables may be SCTC or SVTC. The strategy for these is to have a text file that either gives the value for the variable if it is SCTC or the corresponding spatial grid (netCDF) file if it is SVTC. Input variables may be SCTV or SVTV. The strategy for these is to have a text file that either gives the value for the variable for each time step if it is SCTV, or the name of a grid file holding the value for each time step if it is SVTV. Output variables are grouped into grid output and aggregated outputs. Grid outputs are SVTV. The strategy is to have a text file that lists the grid output variables to be written. These will then be output as netCDF files. Similarly a text file will specify which aggregate variables to output and outputs will go into text files.

The first table below summarizes the function of the files used in the model. Figure 1 illustrates the files used. A specification of the format of each of the files then follows.

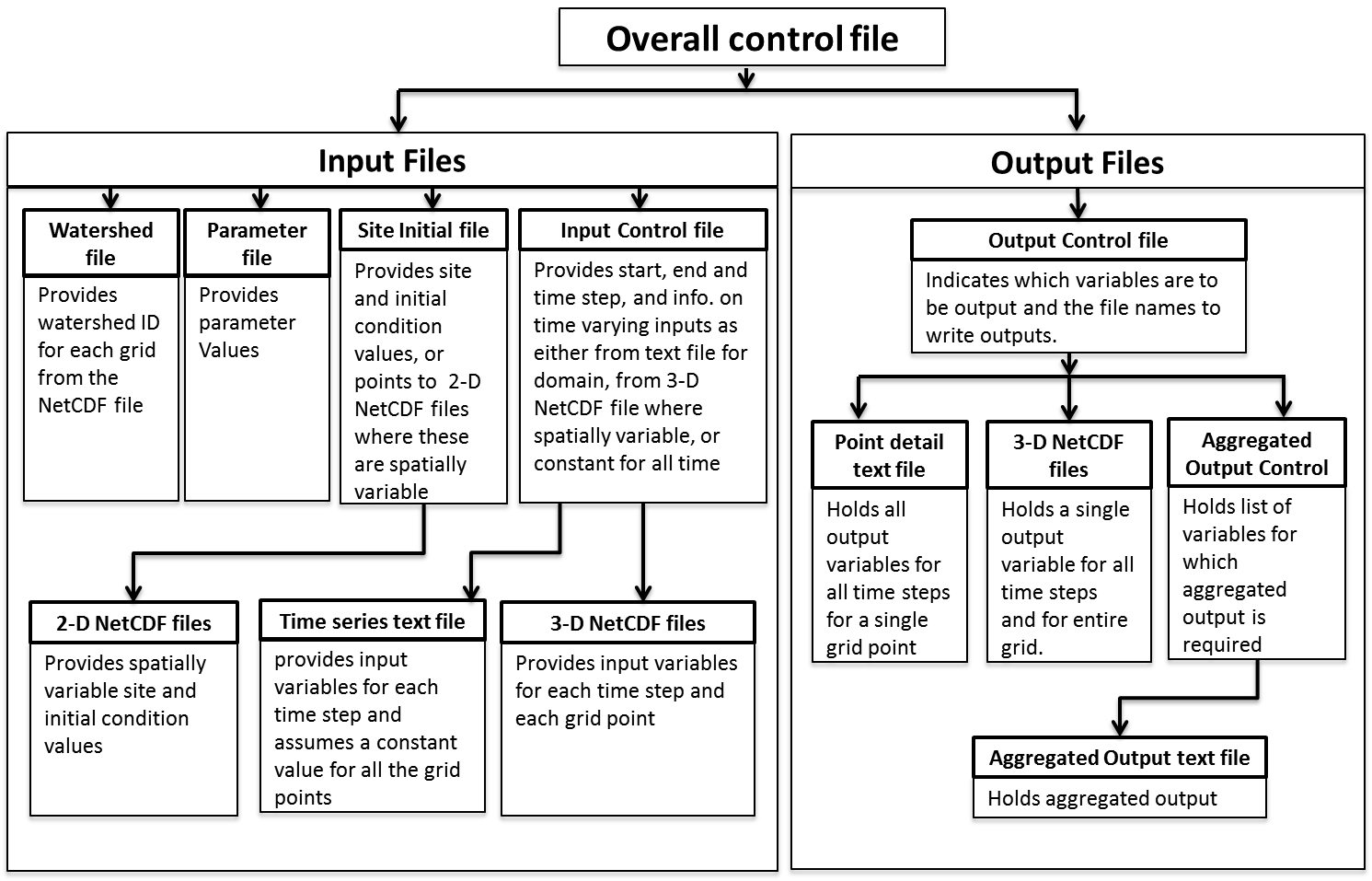


Figure 1. Input/Output Control Schematic

**Summary of UEBGrid snowmelt model input and output file**

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| --- | --- |
| File name | Description |
| overallcontrol.dat | Model Driver: instantiates the model and controls run |
| param.dat | Model parameters file. |
| siteinitial.dat | Contain the site variable, values for each variable or name of grid file that contains the values |
| inputcontrol.dat | Control file that indicates for each variable whether it is SCTV or SVTV and the data or index file for the data. |
| outputcontrol.dat | Control file that indicates for each possible output variable whether it is to be output. |
| watershed.nc | A 2D grid file that has integer values identifying each watershed (really an aggregation domain. It does not matter to the snow model whether they are watersheds or not. Aggregation domains are simply the set of grid cells aggregated together for output) |
| aggregateoutputcontrol.dat | Control file that indicates for each possible output variable whether its aggregate outputs are to output |
| output.dat | Aggregated output variables |

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| **File Name** | **Overallcontrol.dat** | | |
| **File Function** | Provides control over the entire UEBGrid model | | |
| **FileFormat** | Files contains 8 lines | | |
| **Lines description** | **Line** | **Type** | **Description** |
| 1 | text | Descriptive text not used by the model but available to label and describe this file |
| 2 | text | Name of the file containing model SCTC parameters (including Bristow-Campbell parameters). Referred to in this document as param.dat |
| 3 | text | Name of the file containing site variables and initial conditions. Referred to in this document as siteinitial.dat. This file will specify the variable value in the case of SCTC variables or the name of the grid file containing SVTC information. |
| 4 | text | Name of file that specifies the reading of input variables. Input variables are either SCTV or SVTV. If the variable is SCTV, a text file of time series for that variable is named. If the variable is SVTV, then a file listing the NetCDF files that hold the input values for multiple time step is given |
| 5 | text | Name of file that specifies gridded output |
| 6 | text | Name of a 2D netCDF file that contains integer values identifying each watershed followed by tag value pairs giving the name of the X-coordinate, Y-coordinate and name of variable used to define the watershed. Tag value pairs are separated by semicolons, with the tag and value separated by a colon. Valid tags are X, Y, and D for the X-coordinate, Y-coordinate and data respectively. If the netDCF file is such that the Y-coordinate is the first dimension, X-coordinate the second dimension, then X and Y do not need to be given. However D for the data value name always needs to be given. E.g.  Watershed.nc;D:IDnumber  is a valid line 6. |
| 7 | text | Name of file that specifies the aggregated variables to be output |
| 8 | text | Name of file where aggregated outputs will be written |
| Example file | UEBGrid Model Driver  param.dat  siteinitial.dat  inputcontrol.dat  outputcontrol.dat  watershed.nc;X:longitude;Y:latitude;D:IDnumber  Aggregateoutputcontrol.dat  AggregatedOutput.dat | | |

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| **File Name** | **param.dat** |
| **File Function** | Provides the parameter values for the model |
| **File Format** | First line is the header that is not parsed. The remaining lines are read in pairs. The first line in the pair starts with a parameter code that is a fixed string used to identify what parameter value comes on the next line. The code ends in a colon ":" The parameter description may be given following the colon and is not parsed. The next line contains one numeric value and is the parameter value in free format. |
| **File Example** | Model Parameters  irad: Radiation control flag (0=from ta, 1= input qsi, 2= input qsi,qli 3= input qnet)  0  ireadalb: Albedo reading control flag (0=albedo is computed internally, 1 albedo is read)  0  tr: Temperature above which all is rain (3 C)  3  ts: Temperature below which all is snow (-1 C)  -1  ems: Emissivity of snow (nominally 0.99)  0.99  cg: Ground heat capacity (nominally 2.09 KJ/kg/C)  2.09  z: Nominal meas. heights for air temp. and humidity (2m)  2  zo: Surface aerodynamic roughness (m)  0.010  rho: Snow Density (Nominally 450 kg/m^3)  337  rhog: Soil Density (nominally 1700 kg/m^3)  1700  lc: Liquid holding capacity of snow (0.05)  0.05  ks: Snow Saturated hydraulic conductivity (20 m/hr)  20  de: Thermally active depth of soil (0.1 m)  0.1  avo: Visual new snow albedo (0.95)  0.85  anir0: NIR new snow albedo (0.65)  0.65  lans: The thermal conductivity of fresh (dry) snow  1.0  lang: the thermal conductivity of soil  4.0  wlf: Low frequency fluctuation in deep snow/soil layer  0.0654  rd1: Amplitude correction coefficient of heat conduction (1)  1  dnews: The threshold depth of for new snow (0.001 m)  0.001  emc: Emissivity of canopy  0.98  alpha: Scattering coefficient for solar radiation  0.5  alphal: Scattering coefficient for long wave radiation  0.0  g: leaf orientation with respect to zenith angle  0.5  uc: Unloading rate coefficient (Per hour) (Hedstrom and Pomeroy, 1998)  .004626286  as: Fraction of extraterrestrial radiation on cloudy day, Shuttleworth (1993)  0.25  Bs: (as+bs):Fraction of extraterrestrial radiation on clear day, Shuttleworth  .5  lambda: Ratio of direct atm radiation to diffuse, worked out from Dingman  .857143  rimax: Maximum value of Richardson number for stability correction  0.16  wcoeff: Wind decay coefficient for the forest  0.5  a: A in Bristow-Campbell formula for atmospheric transmittance  0.8  c: C in Bristow-Campbell formula for atmospheric transmittance  2.4 |

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| **File Name** | **siteinitial.dat** |
| **File Function** | Provides site variables that may be SVTC or SCTC |
| **File Format** | First line of this file is a header that is not parsed. Depending on the spatially variable flags, the remaining lines occur in groups of 3 or 6. There are three lines for variables that are not spatially variable (SCTC) as follows:  1. Variable code. Variable code is a fixed string used by UEB to identify a variable (see siteinitial variable code list below). The code ends in a colon ":" The variable description may be given following the colon and is not read by the program.  2. Variable flag (for SCTC this will be 0). Variable flag is an integer numeric value, either 1 or 0. 0 indicates the variable is SCTC and only one value will be assigned to it. In this case, third line is the numeric value for that variable.  3. Variable value  There are three lines for variables that are spatially variable  1. Variable code. Variable code as above.  2. Variable flag (for SVTC this will be 1). As above. A flag value of 1 indicates variable is SVTC. In this case, third line in the group is the file name of that netCDF file, the names of the dimension/variables used inside the netCDF file for the X-coordinate, Y-coordinate and data variable.  3. Name of NetCDF file holding the data followed by tag value pairs giving the name of the X-coordinate, Y-coordinate and name of variable used within the NetCDF file for this variable. Tag value pairs are separated by semicolons, with the tag and value separated by a colon. Valid tags are X, Y, and D for the X-coordinate, Y-coordinate and data respectively. If the netDCF file is such that the Y-coordinate is the first dimension, X-coordinate the second dimension, then X and Y do not need to be given. However D for the data value name always needs to be given.  An example is shown below:    LangtangKholaWatershed.nc;X:longitude;Y:latitude;D:watershed  In ‘LangtangKholaWatershed.nc’ netCDF file, ‘longitude’, ‘latitude’ and ‘watershed’ are the names of the X, Y and variable (data), respectively. The order of the tags, X, Y and D does not matter as the model uses the tags to distinguish between each of these.  In the case that defaults are used:  LangtangKholaWatershed.nc;D:watershed  In ‘LangtangKholaWatershed.nc’ netCDF file, ‘watershed’ is the variable (data) name in the file. Y-and X-coordinates must be the 1st and 2nd dimensions of this netCDF file.  The example below lists the inputs required, though the user has the option to set the spatially variable flag indicating whether the data is to come from a file. The order of variables does not matter. |
| **File Example** | Site and Initial Condition Input Variables  USic: Energy content initial condition (kg m-3)  0  0  WSis: Snow water equivalent initial condition (m)  0  0  Tic: Snow surface dimensionless age initial condition  0  0  WCic: Snow water equivalent dimensionless age initial condition (m)  0  0  df: Drift factor multiplier  0  1.0  apr: Average atmospheric pressure  0  74051  Aep: Albedo extinction coefficient  0  0.1  cc: Canopy coverage fraction  1  ccgridfile.nc;D:cc  hcan: Canopy height  1  hcanfile.nc;X:xcoord;Y:ycoord;D:hcan  lai: Leaf area index  1  laifile.nc;D:lai  Sbar: Maximum snow load held per unit branch area  0  6.6  ycage: Forest age flag for wind speed profile parameterization  0  1.00  slope: A 2-D grid that contains the slope at each grid point  1  slope.nc;X:xcoord;Y:ycoord;D:slope  aspect: A 2-D grid that contains the aspect at each grid point  1  aspect.nc;X:xcoord;Y:ycoord;D:aspect  latitude: A 2-D grid that contains the latitude at each grid point  1  lat.nc;D:latitude  subalb: Albedo (fraction 0-1) of the substrate beneath the snow (ground, or glacier)  0  0.25  subtype: Type of beneath snow substrate encoded as (0 = Ground/Non Glacier, 1=Clean Ice/glacier, 2= Debris covered ice/glacier, 3= Glacier snow accumulation zone)  1  SubType.nc;X:xcoord;Y:ycoord;D:SubsurfaceType  gsurf: The fraction of surface melt that runs off (e.g. from a glacier)  0  0  b01: Bristow-Campbell B for January (1)  0  6.743  b02: Bristow-Campbell B for February (2)  0  7.927  b03: Bristow-Campbell B for March(3)  0  8.055  b04: Bristow-Campbell B for April (4)  0  8.602  b05: Bristow-Campbell B for may (5)  0  8.43  b06: Bristow-Campbell B for June (6)  0  9.76  b07: Bristow-Campbell B for July (7)  0  0.00  b08: Bristow-Campbell B for August (8)  0  0.00  b09: Bristow-Campbell B for September (9)  0  0.00  b10: Bristow-Campbell B for October (10)  0  7.4  b11: Bristow-Campbell B for November (11)  0  9.14  b12: Bristow-Campbell B for December (12)  0  6.67  ts\_last: degree Celsius  0  -9999  longitude: A 2-D grid that contains the longitude at each grid  1  longitude.nc;X:xcoord;Y:ycoord;D:longitude |

Table of site initial variable codes

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| **Code** | **Definition** |
| USic | Energy content initial condition (kg m-3) |
| WSic | Snow water equivalent initial condition (m) |
| Tic | Canopy Snow Water Equivalent (m) relative to T = 0 C solid phase |
| WCic | Dimensionless age of snow surface (or albedo - depending on iflag) |
| df | Drift factor multiplier |
| apr | Average atmospheric pressure |
| Aep | Albedo extinction coefficient |
| cc | Canopy coverage fraction |
| hcan | Canopy height |
| lai | Leaf area index |
| Sbar | Maximum snow load held per unit branch area |
| ycage | Forest age flag for wind speed profile parameterization |
| slope | A 2-D grid that contains the slope (in degrees) at each grid point |
| aspect | A 2-D grid that contains the aspect (in degrees clockwise from north) at each grid point |
| latitude | A 2-D grid that contains the latitude (in degrees) at each grid point |
| longitude | A 2-D grid that contains the longitude (in degrees) at each grid point |
| subalb | Albedo (fraction 0-1) of the substrate beneath the snow (ground, or glacier) |
| subtype | Type of beneath snow substrate encoded as (0 = Ground/Non Glacier, 1=Clean Ice/glacier, 2= Debris covered ice/glacier, 3= Glacier snow accumulation zone) |
| gsurf | The fraction of surface melt that runs off (e.g. from a glacier) |
| Ts\_last | Snow surface temperature one day prior to the model starting time |
| b01 | Bristow-Campbell B for January (1) |
| b02 | Bristow-Campbell B for February (2) |
| b03 | Bristow-Campbell B for March(3) |
| b04 | Bristow-Campbell B for April (4) |
| b05 | Bristow-Campbell B for may (5) |
| b06 | Bristow-Campbell B for June (6) |
| b07 | Bristow-Campbell B for July (7) |
| b08 | Bristow-Campbell B for August (8) |
| b09 | Bristow-Campbell B for September (9) |
| b10 | Bristow-Campbell B for October (10) |
| b11 | Bristow-Campbell B for November (11) |
| b12 | Bristow-Campbell B for December (12) |

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| **File Name** | **inputcontrol.dat** |
| **File Function** | Identifies time varying input data. Input variables are either SCTV or SVTV (but with SCTC allowed). In the SCTV case this file specifies the name of the file holding the time series. In the SVTV case this file specifies the name of a text file listing the NetCDF files giving the SVTV input. In the SCTC case a numeric value is given. |
| **File Format** | First line of this file is a header that is not parsed. Second line is the starting date time for the model and third line is the ending time. Fourth line is increment of time (dt) from one time step to another. The fifth line gives the UTC offset in hours for times used in the model inputs. **All time inputs for a specific model run should be with respect to the same UTC offset (time zone). This applies to both text and NetCDF files that contain time values.**  UTC offset is the number of hours that need to be subtracted from an input time value to get UTC time.  The handling of time in the code will be as follows  UTCtime = inputtime - UTCOffset (in hours)  modellocaltime = UTC time+longitude/15 (in hours)  e.g. if input time is 11:00 and UTC offset is -7 (as it would be for Utah) then the corresponding UTC time is 11 - (-7) = 18:00.  Now if the longitude is -104 (104 W) then modeltime = 18 -104/15=11.06 hr  Depending on the spatially variable flags, the remaining lines occur in groups of 3 or 7. There are three lines for variables that are not spatially variable (SCTV or SCTC) as follows:  1. Variable code  2. Variable flag (for SCTC this will be 2, for SCTV this will be 0)  3. Variable value (for SCTC) or name of file text file with inputs for SCTV  There are seven lines for variables that are spatially and time variable (SVTV)  1. Variable code  2. Variable flag (for SVTV this will be 1)  3. Name of file holding list of NetCDF files from which input is to be read followed by tag value pairs giving the name of the time dimension, X-coordinate, Y-coordinate, and name of variable used within the NetCDF file for this variable. Tag value pairs are separated by semicolons, with the tag and value separated by a colon. Valid tags are T, X, Y and D for the time dimension, X-coordinate, Y-coordinate and data respectively. If the netDCF file is such that time is the first dimension, the Y-coordinate the second dimension, and X-coordinate the third dimension, then T, X and Y do not need to be given. However D for the data value name always needs to be given. There is also the option to specify a range tag followed by bounding values (comma separated) for the data. Data outside of this range will be treated as no-data and a warning message written.  An example of third line of a SVTV variable is shown below:  QsiIndex.Dat;X:longitude;Y:latitude;time:time;D:shortwave;range:0&4914  The file QsiIndex.Dat is a text file that lists all the netCDF file names for variable Qsi (shortwave radiation). In those netCDF file(s), ‘longitude’, ‘latitude’, time and ‘shortwave’ are the names of the X, Y, time and variable (data), respectively. By reading the tags X, Y, time and D, model identifies the corresponding netCDF name. A tag value pair appears together and separated by a colon’:’ Each set of dimensions/variables are separated by a semicolon ‘;’. ‘range’ is the maximum and minimum possible value for that variable. Shortwave radiation cannot be less than 0 and cannot exceed solar constant (1365 Wm-2/ 4914 kJ m-2hr-2). Therefore, range is between 0 and 4914 and these two values are separated by ‘&’. If input is outside this range, a warning is written and the model follows the no-data action for that variable for that time step. Specifying range is optional; a user may not need to write it if s/he is confident about the input data.  In case UEBGrid default are used:  QsiIndex.Dat; D:shortwave;range:0&4914  The file QsiIndex.Dat is a text file that lists all the netCDF file names for variable Qsi (shortwave radiation). ‘shortwave’ is the variable name in these netCDF files. time-,Y- and X-coordinates must be the 1st, 2nd and 3rd dimensions in these netCDF files, respectively.  The example below notes which inputs are required and which are not depending on control options. |
| **File Example** | Input Control file  2009 10 01 00 yyyy mm dd hh.hh (starting date)  2010 06 29 23 yyyy mm dd hh.hh (ending date)  1.00 (dt=increment in two consecutive time step in hours)  -7.0 UTCOffSet for the times that are input to the model. Use 0 for input times in UTC. (-7 is US Mountain time zone)  Ta: Air temperature (always required)  1  TaIndex.dat;D:Ta  Prec: Precipitation (always required)  0  Prec.dat  v: Wind speed (always required)  0  V.dat  RH: Relative Humidity (always required)  0  RH.dat  Qg: Ground heat flux (kJ/m2/hr)  2  0  Qsi: incoming solar radiation (kJ/m2/hr)  0  Qsi.Dat |

Table of input variable codes

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| **Code** | **Definition** |
| Ta | Air temperature (always required) |
| Prec | Precipitation (always required) |
| v | Wind speed (always required) |
| RH | Relative Humidity (always required) |
| Qsi | Incoming shortwave(kJ/m2/hr) (only required if irad=1 or 2) |
| Qli | Long wave radiation(kJ/m2/hr) |
| Qnet | Net radiation(kJ/m2/hr) (only required if irad=3) |
| Snowalb | Snow albedo (0-1). (only required if ireadalb=1) The albedo of the snow surface to be used when the internal albedo calculations are to be overridden |
| Qg | Ground heat flux (kJ/m2/hr) |

**Example time series input file format**

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| --- | --- | --- | --- |
| **File Name** | **LongwaveRadiationTimeseries.dat** | | |
| **File Function** | Provides values of longwave radiation time series which is spatially constant but time varying | | |
| **File Format** | File contains multiple lines. First line is header which contains the variable code, up to the colon. Information beyond the colon not read. Remaining lines contain five columns | | |
| **Lines description** | **Column** | **Type** | **Description** |
| 1-4 | numeric | Time step (format: YYYY MM DD HH.FFF) |
|  | 5 | numeric | Numeric Value of a variable at a particular time step |
| **Example file** | Qli: Incident longwave radiation  2011 11 26 03.00 34.01  2011 11 26 06.00 34.01  2011 11 26 09.00 32.40  2011 11 26 12.00 33.40  2011 11 27 15.00 31.40  2011 11 26 18.00 34.01  2011 11 26 21.00 32.96 | | |

**Example grid series input file format**

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| --- | --- | --- | --- |
| **File Name** | netCDFFileList.dat | | |
| **File Function** | Provides names of gridded (netCDF files) | | |
| **File Format** | File contains multiple lines. Each line of this file contains the name of a netCDF file. Each netCDF file may contain one or more input variables and multiple time steps. When taken collectively all files need to provide input data for all time steps. There is no input requirement as to how many or how few time steps, variables or input files are used. The program orders the files by their internal start time and works its way through the files reading inputs as needed. Any input value in a file is assumed to persist until the next input value in the file. Values from one file are assumed to persist until there is a new file with new start time. Any input values needed before the earliest file start time are taken as the first values in the earliest file start time. This intended to be a general and robust input model that allows the user flexibility to have netCDF files organized say into all variables for each day, or one or more netCDF files with single variables spanning longer periods. | | |
| **Lines description** | **Column** | **Type** | **Description** |
| 1 | text | Name of the netCDF file |
| **Example file** | 20111126.nc  20111127.nc  20111128.nc  20111129.nc | | |

**Note on time steps and synchronization**

The model adopts the approach that any SCTV or SVTV value persists until another later time value is available. This means that if any input time series data value is missing (either spatially constant or variable in a netCDF file) the previous time step value will be repeated.

**Output control file format**

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| --- | --- |
| **File Name** | **outputcontrol.txt** |
| **File Function** | Identifies the variables for which gridded output is to be produced |
| **File Format** | First line is the header and is not parsed  The remaining lines are in groups.  The first line for each group gives the codes for variables that are to be output into a netcdf file for the entire grid domain or a special code 'pointdetail' to specify output of a point in the domain to an ASCII text file using the ASCII text file format from the earlier point version of UEB.  In the case of netCDF grid outputs, there are two lines in each group. The first line is an output variable code from the list below. The second line in the group gives a netcdf file name (that may include a folder path) for the output raster series. Output files are netCDF grids. In the event that the output data exceeds the capacity of the given netcdf file, additional netcdf files are created suffixed by a number. For example the input  atf: Atmospheric transmission factor  outputs\atf.nc  would produce files  output\atf.nc  output\atf0002.nc  output\atf0003..nc  ...  in the folder 'output\'. This folder has to exist before UEB is run or else an error will result. UEB has not been programmed to create or manage folders. This is the responsibility of the user.  Similarly the input  SWIT: Total outflow (m/hr)  switdir\swit.nc  would produce output files, in the 'switdir' folder in this example  switdir\swit.nc  switdir \swit0002.nc  switdir \swit0003.nc  ...  The number of additional files named \*0002.nc, \*0003.nc etc is determined internally by UEB based on restricting each netcdf file to have no more than about 270000000 data values which results in a maximum netcdf file size around 1.5 GB  In the case of 'pointdetail' output there are three lines in each group. The first line of the group holds the code 'pointdetail' The second line should be 2 space separated integer values giving the row and column position of a particular grid point for which point detail output is to be produced. The third line of the group is the name of the text file where point detail output is written. For example:  pointdetail: An output point  1 2  outputs\Point12file.txt  As with netcdf files UEBGrid does not deal with folder creation so the folder 'outputs\' would have to exist for the above to work. |
| **File Example** | List of Output Variables  atf: Atmospheric transmission factor  outputs\atf.nc  hri: Radiation index  outputs\hri.nc  Ub: Energy content (kJ/m2)  outputs\ub.nc  SWE: Surface snow water equivalent (m)  outputs\swe.nc  pointdetail: An output point  1 2  outputs\Point12file.txt  SWIT: Total outflow (m/hr)  outputs\swit.nc |

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| **File Name** | **pointdetail.dat** |
| **File Function** | Contains detailed output at a single point |
| **FileFormat** | Files contains free format numbers in groups of 67 per time step |
| **Data description** | The following data is output in free format for each time step at the specified point  1 Year Beginning of time step year  2 Month Beginning of time step month  3 Day Beginning of time step day  4 Hour Beginning of time step hour  5 ATF-BC Atmospheric transmisison factor  6 HRI Radiation index  7 Eacl Clear sky emissivity  8 Ema Atmospheric emissivity  9 Ta(C) Air temperature  10 P(m/hr) Precipitation  11 V(m/s) Wind speed  12 RH Relative humidity  13 Qsi(kJ/m2/hr) Incoming solar radiation  14 Qli(kJ/m2/hr) Incoming longwave radiation  15 QnetOb(kJ/m2/hr) Observed net radiation  16 Cos(Zen) Cos of solar zenith angle  17 Ub(kJ/m2) Energy content  18 SWE(m) surface snow water equivalent  19 tausn Dimensionless age of the snow surface  20 Prain(m/hr) Precipitaion in the form of rain  21 Psnow(m/hr) Precipitaion in the form of snow  22 Albedo Albedo  23 Qh(kJ/m2/hr) Surface Sensible heat flux  24 Qe(kJ/m2/hr) Surface Latent heat flux  25 E(m) Surface sublimation  26 SWIT (m/hr) Total outflow  27 Qm(kJ/m2/hr) Surface melt energy  28 Q(kJ/m2/hr) Net surface energy exchange  29 dM/dt(m/hr) Net surface mass exchange  30 Tave(C) Average snow temperature  31 Ts(C) Surface snow temperature  32 CumP(m) Cumulative precipitation  33 CumE(m) Cumulative surface sublimation  34 CumMelt(m) Cumulative surface melt  35 NetRads(kJ/m2/hr) Modeled surface net radiation  36 Smelt(m/hr) Melt generated at surface  37 refDep(m) Depth of penetration of top refreezing front  38 totRefDep(m) Total depth of refreezing (see You dissertation)  39 Cf Cloudiness fraction  40 Taufb Direct solar radiation fraction  41 Taufd Diffuse solar radiation fraction  42 Qsib Direct solar radiation  43 Qsid Diffuse solar radiation  44 Taub Direct solar radiation canopy transmission fraction  45 Taud Diffuse solar radiation canopy transmission fraction  46 Qsns(kJ/m2/hr) Solar radiation absorbed at surface  47 Qsnc(kJ/m2/hr) Solar radiation absorbed in canopy  48 Qlns(kJ/m2/hr) Longwave radiation absorbed at surface  49 Qlnc(kJ/m2/hr) Longwave radiation absorbed in canopy  50 Vz(m/s) Modeled wind beneath canopy  51 Inmax(m) Canopy snow interception capacity  52 int(m/h) Canopy snow interception  53 ieff(m/hr) Fraction of precipitation intercepted (interception efficiency)  54 Ur(m/hr) Canopy mass unloading  55 SWEc(m) Canopy snow water equivalent  56 Tc(C) Canopy temperature  57 Tac(C) Air temperature within canopy  58 QHc(kJ/m2/hr) Canopy sensible heat flux  59 QEc(kJ/m2/hr) Canopy latent heat flux  60 Ec(m/hr) Canopy sublimation  61 Qpc(kJ/m2/hr) Precipitaiton energy advected to canopy  62 Qmc(kJ/m2/hr) Canopy melt energy  63 Mc(m/hr) Melt from canopy  64 FMc(m/hr) Net canopy energy exchange  65 MassError(m) Mass balance closure error  66 SWIGM (m/hr) Glacier melt outflow  67 SWIR (m/hr) Rainfall outflow  68 SWISM (m/hr) Snow melt outflow |
| **Example file** | 2009 10 1 0.0000000E+00 0.4170006  0.0000000E+00 0.7425536 0.9140126 -7.355000 0.0000000E+00  4.405000 0.8946500 0.0000000E+00 946.4433 0.0000000E+00  0.0000000E+00  -306.8772 0.0000000E+00 3.9321752E-03 0.0000000E+00 0.0000000E+00  0.2500000 -202.3752 0.0000000E+00 0.0000000E+00 0.0000000E+00  0.0000000E+00 -306.8772 0.0000000E+00 -0.8637130 -2.325256  0.0000000E+00 0.0000000E+00 0.0000000E+00 -104.5020 0.0000000E+00  0.0000000E+00 0.0000000E+00 0.6659988 0.2147151 0.2022855  0.0000000E+00 0.0000000E+00 0.0000000E+00 0.1829317 0.0000000E+00  0.0000000E+00 -104.5020 23.11230  42.68610 1.6976908E-02 0.0000000E+00 0.0000000E+00 0.0000000E+00  0.0000000E+00 -7.148926 -7.187934 -23.11698 0.0000000E+00  0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00  0.0000000E+00 0.0000000E+00 0.0000000E+00  0.0000000E+00 |

|  |  |  |  |
| --- | --- | --- | --- |
| **File Name** | **watershed.nc** | | |
| **File Function** | A 2D grid file that contain integer values identifying each watershed (really an aggregation domain - the snow model does not care whether they are watersheds or not, or even contiguous) | | |
| **File Format** | NetCDF  Attribute: Unit less  Variable: watershed Identification Number (integer) | | |
| **Fields description** | **Field** | **Type** | **Description** |
| watershed number | Numeric, float, -9999 indicates no watershed | Each watershed will be numbered and each number within a grid will represent that particular watershed |
| **File Example** | 1 1 1 1 1 1 1 1 1 2  0 0 1 1 1 1 1 1 2 2  0 0 0 1 1 1 1 2 2 2  0 0 0 0 1 1 1 2 2 3  0 0 0 0 0 1 2 2 3 3  0 0 0 0 0 0 2 3 3 3 | | |

|  |  |
| --- | --- |
| **File Name** | **aggregatedoutputcontrol.dat** |
| **File Function** | Identifies the variables for which aggregated output is to be produced |
| **File Format** | First line is the header that is not parsed. The remaining lines give the codes for variables that are to be aggregated output. The code ends in a colon ":" The parameter description may be given following the colon and is not read by the program. |
| **File Example** | List of Aggregated Output Variables  P: Precipitation (m/hr)  SWE: Surface snow water equivalent (m)  SWIT: Total outflow (m/hr) |

|  |  |  |  |
| --- | --- | --- | --- |
| **File Name** | **AggregatedOutput.dat** | | |
| **File Function** | Contains aggregated output | | |
| **FileFormat** | Files contains 7 columns | | |
| **Lines description** | **Line** | **Type** | **Description** |
| 1 | text | Header comprised of Year Month Day Hour Variable Watershed Value |
|  | 2 and on | Mixed space separated | Values |
| **Column description** | **Column** | **Type** | **Description** |
|  | 1-4 | numeric | Date time in format: YYYY MM DD HH.FFF) |
|  | 5 | text | Variable code |
|  | 6 | numeric | Watershed id |
|  | 7 | numeric | Aggregated value |
| **Example file** | Year month day hour variable watershed value  2011 11 26 06.33 swe 1 0.3  2011 11 26 12.33 swe 1 0.4  2011 11 26 18.33 swe 1 0.35  2011 11 26 24.33 swe 2 0.45  ... | | |

## Beginning of interval time specification

UEB uses a beginning of interval interpretation of time varying inputs and outputs. This means that if, for example rainfall and radiation inputs are reported at 6 hr time steps at 6:00, 12:00, 18:00 etc, the 6:00 value is taken to apply from 6:00 to 12:00, the 12:00 value is taken to apply from 12:00 to 18:00 and so on.

**NetCDF file requirements**

UEBGrid works with 2-D and 3-D netCDF files. 2-D netCDF files are used to store variables that are constant in time (Spatially variable and time constant SVTC), while 3-D netCDF files are used to store variables that change in time (Spatially variable and time variable SVTV).

The characteristics of a netCDF file required by UEBGrid are:

* The grid sizes have to be the same across all netCDF files used in any one UEBgrid run. There is no exception to this rule.
* 3-D netCDF files require a time dimension.
* A single variable may be stored in multiple netCDF files. Dimension and variable names should be the same across all the netCDF files in which that variable is stored in. For example, if "Tair" is stored in both "Temp1.nc" and "Temp2.nc" file and dimensions of "Tair1.nc" are X, Y and Time, dimensions of "Temp2.nc" needs to be X, Y and Time. The order of dimensions needs to be the same for all files holding the same variable. If dimension order appears as (time, Y-coordinate, X-coordinate), user doesn’t have to specify the names of these variables. (In this case they could have different names across different files although this practice is not recommended). However, dimension names can be different for different variable. If "Tair" and "RH" are stored in "Tair.nc" and "Rhval.nc" files and dimensions of "Tair1.nc" are X, Y and Time and dimensions of "Rhval.nc" are Lat, Lon and T, model will work as long as the spatial grid values are consistent.

**For 3-D netCDF files the following are required**

* Unit of time (“time:units”) must be given as one of
  + "hours since ..."
  + "hour since ..."
  + "days since ..."
  + "day since ..."

No other time unit will be recognized. Suitable examples are "hours since 2004-12-01T00.00", or "days since 2004-12-01T00.00. UEBGrid will use these dates and time values to properly order inputs so this information is important.

* The time units (both the reference date AND units - hours or days) should be exactly the same across all netCDF input files.
* Hours (00.00) in the reference date should always be zero.
* Time values should be provided as real (floating) numbers giving fractions of hours or days from the reference date (depending on whether the units are days or hours). For example, if the first time step is 2004-12-03 03.00 and the reference date 2004-12-03 00.00, then first time value is 3.0 for hour units and 0.125 for day units. If input variables are provided every 3 hours then next time values are 6.0, 9.0, 12.00, 15.00, 18.00 etc.
* Time values should be with respect to the time zone and UTC offset specified in the inputcontrol.dat file. This should be the same for all inputs for any model run.

Metadata may be added as attributes inside a NetCDF file but will not be read by the model in most cases. However, metadata may help the users to understand various characteristics of the input data (such as units, data collectors, responsible organization, coordinate systems and projects etc.).

**Running UEBGrid in point mode.**

UEBGrid may be run at a single point without spatially variable input data. The following input files are required. In addition the overall control file should be limited to 4 lines omitting the specification of gridded output information. Point mode is detected by the model encountering an end of file in overall control before gridded information is read.

|  |  |
| --- | --- |
| File name | Description |
| overallcontrol.dat | Model Driver: instantiates the model and controls run |
| param.dat | Model parameters file. |
| siteinitial.dat | Contain the site variable, values for each variable or name of grid file that contains the values |
| inputcontrol.dat | Control file that indicates for each variable whether it is SCTV or SVTV and the data or index file for the data. |

|  |  |  |  |
| --- | --- | --- | --- |
| **File Name** | **Overallcontrol.dat** | | |
| **File Function** | Provides control over the entire UEBGrid model | | |
| **File Format** | Files contains 4 lines | | |
| **Lines description** | **Line** | **Type** | **Description** |
| 1 | text | Descriptive text not used by the model but available to label and describe this file |
| 2 | text | Name of the file containing model SCTC parameters (including Bristow-Campbell parameters). Referred to in this document as param.dat |
| 3 | text | Name of the file containing site variables and initial conditions. Referred to in this document as siteinitial.dat. This file will specify the variable value in the case of SCTC variables. |
| 4 | text | Name of file that specifies the reading of input variables. Input variables are either SCTC or SCTV. If the variable is SCTV, a text file of time series for that variable is named. If the variable is SCTC, This file will specify the variable value. |
| Example file | UEBGrid Model Driver  param.dat  siteinitial.dat  inputcontrol.dat | | |

In point mode the following constraints apply

* Watershed filename should not be provided. OverallControl.Dat file contains only 4 lines.
* No site, initial or input variables are stored in netCDF file. Variables are either SCTC or SCTV. Since model is run for a single point, concept of spatial variability no longer exists.
* There is no necessity of creating an output folder. Only one text file will be created to store the outputs and it is named as ‘PointOutput.Dat’ and it will be created in the folder where all input file exist.

**Codes for output variables**

ATF-BC: Atmospheric transmission factor

HRI: Radiation index

Eacl: Clear sky emissivity

Ema: Atmospheric emissivity

Ta: Air temperature(C)

P: Precipitation (m/hr)

V: Wind speed (m/s)

RH: Relative humidity

Qsi: Incoming solar radiation (kJ/m2/hr)

Qli: Incoming longwave radiation (kJ/m2/hr)

Qnet: Input net radiation (kJ/m2/hr)

Os: Cos of solar zenith angle (Zen)

Ub: Energy content (kJ/m2)

SWE: Surface snow water equivalent (m)

tausn: Dimensionless age of the snow surface

Prain: Precipitation in the form of rain (m/hr)

Psnow: Precipitation in the form of snow (m/hr):

Qh: Surface Sensible heat flux (kJ/m2/hr):

Qe: Surface Latent heat flux (kJ/m2/hr)

E: Surface sublimation (m):

SWIT: Total outflow (m/hr). This combines rainfall (in the case of no snow/glacier) snow/glacier melt, and it the surface water input to the runoff generation process.

SWIGM: Glacier melt outflow (m/hr). This is the part of total outflow that originates from glacier melting.

SWIR: Rainfall outflow (m/hr). This is the part of total outflow that is from rainfall in the case of no snow/glacier.

SWISM: Snow melt outflow (m/hr). This is the part of total outflow that originates from the melting of seasonal snow pack (as distinct from glacier ice)

Qm: Surface melt energy (kJ/m2/hr)

Q: Net surface energy exchange (kJ/m2/hr)

dMdt: Net surface mass exchange (m/h)

Tave: Average snow temperature (C)

Ts: Surface snow temperature (C)

CumP: Cumulative precipitation (m)

CumE: Cumulative surface sublimation (m)

CumMelt: Cumulative surface melt (m)

NetRads: Modeled surface net radiation (kJ/m2/hr)

Smelt: Melt generated at surface (m/hr). This is melt generated at the surface and modeled to infiltrate into the snow or glacier where it may refreeze. It is not base of the snow/glacier outflow.

refDep: Depth of penetration of top refreezing (m)

totRefDep: Total depth of refreezing (m)

Cf: Cloudiness fraction

Taufb: Direct solar radiation fraction

Taufd: Diffuse solar radiation fraction

Qsib: Direct solar radiation

Qsid: Diffuse solar radiation

Taub: Direct solar radiation canopy transmission fraction

Taud: Diffuse solar radiation canopy transmission fraction

Qsns: Solar radiation absorbed at surface (kJ/m2/hr)

Qsnc: Solar radiation absorbed in canopy (kJ/m2/hr)

Qlns: Longwave radiation absorbed a tsurface (kJ/m2/hr)

Qlnc: Longwave radiation absorbed in canopy (kJ/m2/hr)

Vz: Modeled wind beneath canopy (m/s)

Inmax: Canopy snow interception capacity (m)

int: Canopy snow interception (m/hr)

ieff: Fraction of precipitation intercepted (m/hr)

Ur: Canopy mass unloading (m/hr)

SWEc: Canopy snow water equivalent (m)

Tc: Canopy temperature(C)

Tac: Air temperature within canopy (C)

QHc: Canopy sensible heat flux (kJ/m2/hr):

QEc: Canopy latent heat flux (kJ/m2/hr):

Ec: Canopy sublimation (m/hr):

Qpc: Precipitation energy advected to canopy (kJ/m2/hr):

Qmc: Canopy melt energy (kJ/m2/hr)

Mc: Melt from canopy (m/hr)

FMc: Net canopy energy exchange (m/hr)

MassError: Mass balance closure error (m)

SWIGM (m/hr) Glacier melt outflow

SWIR (m/hr) Rainfall outflow

SWISM (m/hr) Snow melt outflow